Developing Simulation and Analysis Tools for the EIC

Alexander Kiselev and *Markus Diefenthaler*
for the eRD20 EIC Software Consortium

EIC R&D Meeting, BNL January 2018

BROOKHAVEN NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY | Office of Science
Jefferson Lab
Thomas Jefferson National Accelerator Facility

Global objectives & current focus

- **Our global objectives**
  - Build an active working group of EIC software experts & developers
  - Connect existing software frameworks
  - Establish standards for the future EIC software

    - ***R&D Committee recommendation from Jul'2017 meeting:***

      "… take a more active role in working with the detector consortia to help with the simulations and set up a process to easily implement new detector configurations to optimize the detector design"

- **Our particular present focus**
  - Reach out to the EIC community
    - Communicate present status
    - Bring existing software to the end users
    - Produce publicly available consensus-based documents on critical subjects
    - Provide vision for the future
  - Continue work on common interfaces (geometry, file formats, tracking, etc)
  - Explore new avenues of software development (machine learning, etc)

EIC Software Consortium (ESC) members

ANL (3) W. Armstrong, S. Chekanov, D. Blyth

BNL (4) E.-C. Aschenauer, AK (**co-PI**) , J. Lauret, C. Pinkenburg

Fermilab (1) S. Prestel

INFN Trieste (1) A. Bressan

Jefferson Lab (4) MD (**co-PI**) , D. Lawrence, D. Romanov, M. Ungaro

SLAC (2) M. Asai, A. Dotti

William & Mary (1) W. Deconinck

ESC meeting in Argonne in October 2017

Participants in front for MIRA at ANL

ANL, BNL, FNAL, INFN Trieste, JLab, SLAC, William & Mary

ESC meeting in Argonne in October 2017

09:00 **Vision for ANL software** *30'*
Speaker: Whitney Armstrong (ANL)

09:30 **Status of ANL software** *30'*
Speaker: Dr. David Blyth (ANL)

MC Status

10:15 **HepSim News** *30'*
Speaker: Dr. Sergei Chekanov (ANL)

10:45 **EicMC Integration** *15'*
Speaker: Dr. Alexander Kiselev (BNL)

16:30 **Radiative corrections** *30'*
Speaker: Dr. Andrea Bressan (INFN Trieste)

11:00 **Event visualization** *30'*
Speaker: Dr. Dmitry Arkhipkin (BNL)

Interfaces and integration

10:15 **Geometry interface** *30'*
Speaker: Dr. Andrea Dotti (SLAC)

10:45 **Development of a new data model: ProIO** *30'*
Speaker: Dr. David Blyth (ANL)

14:30 **Development of Containers** *30'*
Speaker: David Lawrence (JLab)

Tracking

15:30 **Towards unified tracking** *30'*
Speaker: Wouter Deconinck (William & Mary)

Geant4 validation

14:30 **Geant4 Validation for HEP** *30'*
Speaker: Dr. Andrea Dotti (SLAC)

15:00 **Test beam comparisons** *15'*
Speaker: Dr. Chris Pinkenburg (BNL)

Lessons learned from ILC

13:30 **SLIC experience** *30'*
Speaker: Dr. Norman Graf (SLAC National Accelerator Laboratory)

- Lead persons exists for each of the major topics …
- … but they really work on a best effort basis

Face-to-face meetings is the most efficient way to come to a consensus and move on

ESC presentations at the EICUG meeting

- Temple University Nov,30-Dec,1 2017
- One full session dedicated to EIC software review and future prospects

11:00	**EIC Software Consortium: Review of EIC Software (25+5)**	*KISELEV, Alexander*
	Kiva Auditorium, Temple University	10:50 - 11:20
	EIC Software Consortium: Vision for EIC Computing (25+5)	*DIEFENTHALER, Markus*
	Kiva Auditorium, Temple University	11:20 - 11:50
12:00	**Discussion (30)**	*DIEFENTHALER, Markus et al.*
	Kiva Auditorium, Temple University	11:50 - 12:20

Overview of existing EIC software frameworks

- *eic-smear, GEMC, fun4all, EicRoot, Argonne software*

Other examples of EIC community software

- *PID consortium software, IR modeling tools, silicon tracker simulations & others*

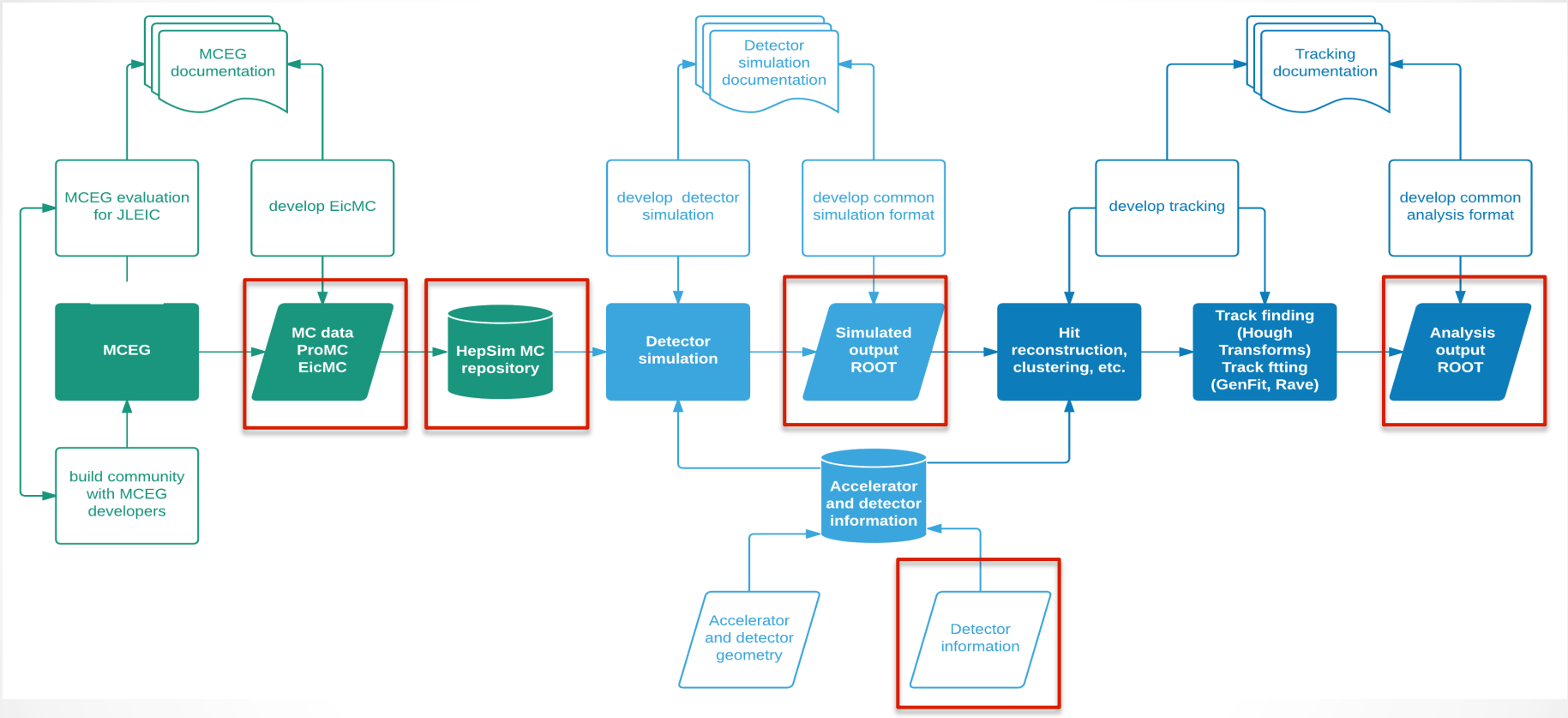
Other software expertise in the community

- *Gas detector simulations, CAD import, FEA tools, PCB engineering & others*

Present community-wide software activities and vision for the future

- *Included in this talk, to a large extent*

Common interfaces

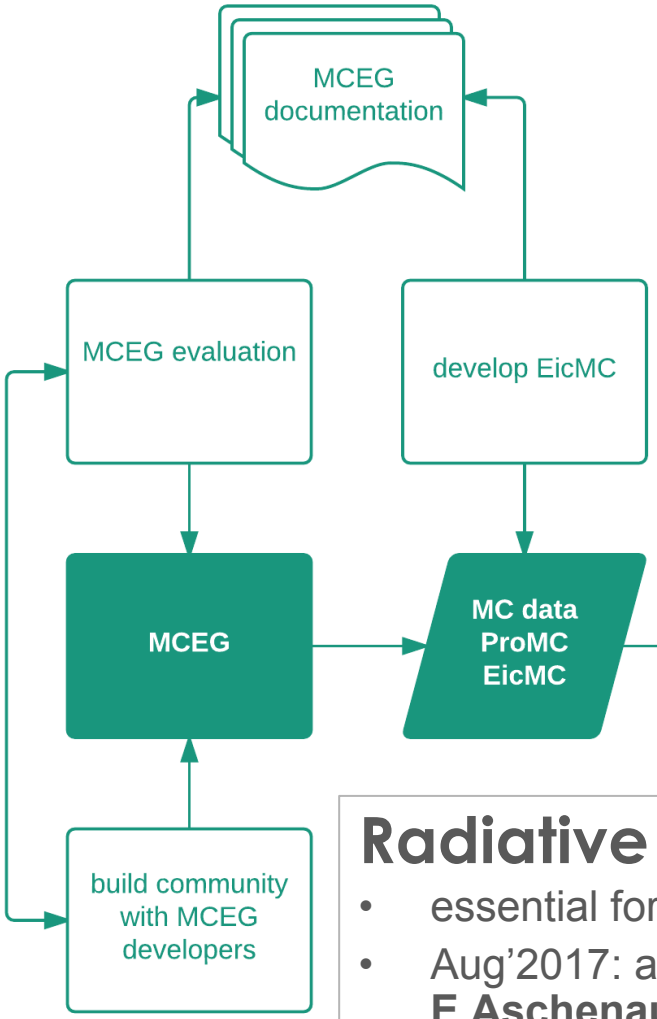


The goal: identify key points and focus on them

Monte-Carlo simulations

EIC MCEG initiative

- emphasize on strong interplay experiment – theory
- connect MCEG efforts NP-HEP



ESC MC format

- self-descriptive data format
- HPC compatible

Radiative correction library

- essential for high-precision measurements at the EIC
- Aug'2017: a very productive meeting between **E.Aschenauer, A.Bressan** and **H.Spiesberger**:
  - start back from HERACLES part of Djangoh
  - work on interface to PYTHIA6/8

Monte-Carlo workshop

Monte Carlo Event Generators for future ep and eA facilities

Satellite Workshop during POETIC8, Mar. 22-23, 2018

Collaboration HEP - NP

Organizers

- **Elke-Caroline Aschenauer** (BNL)
- **Markus Diefenthaler** (JLab)
- **Simon Plätzer** (MCnet, University of Vienna)
- **Stefan Prestel** (FNAL)

Goals

- MCEG requirements for upcoming ep and eA measurements
- Roadmap for MCEG developments for upcoming ep and eA measurements

Self-descriptive file formats

Google protocol buffer based

- flexible
- portable
- no external dependencies

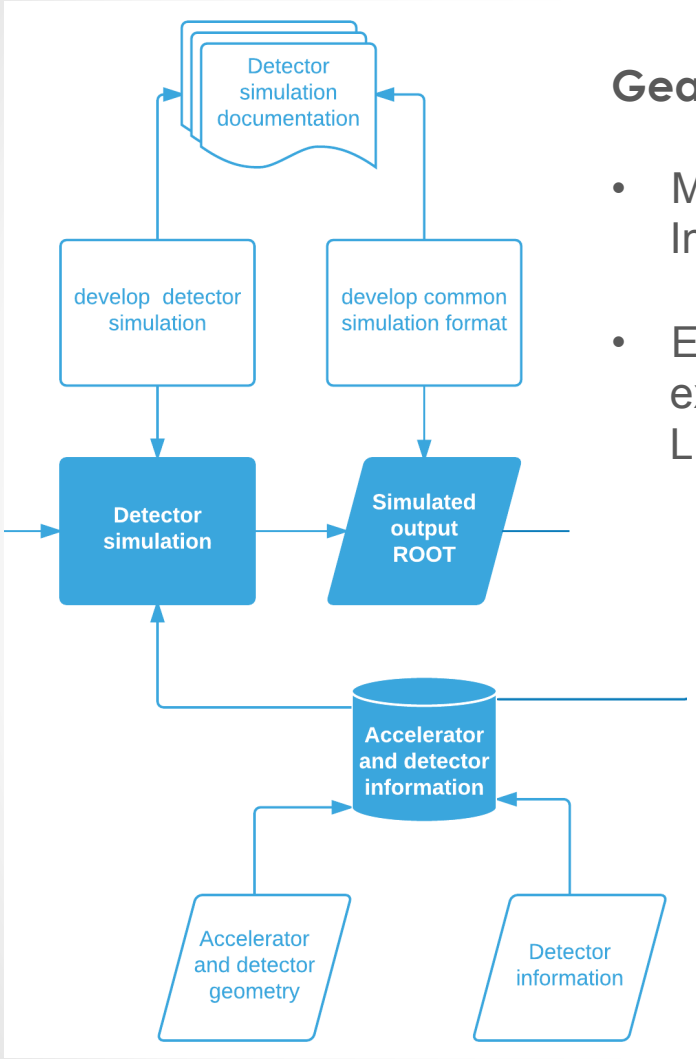
Development history within ESC

- Idea & original version (ProMC) by **S.Chekanov** for HepSim repository
  - limited functionality MC application
- Second version (EicMC) by **AK**
  - MC application with several advanced features
- Present development (ProIO) by **D.Blyth**
  - General-purpose format with multi-language support
  - Very close to the first official release

Community document to be drafted in early FY18

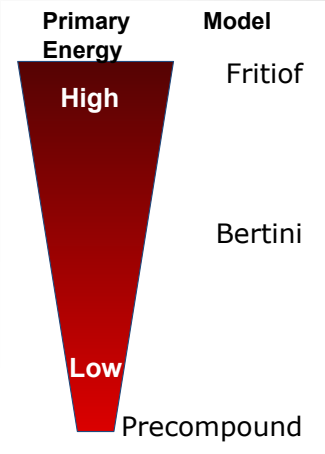
HepSim-related MC application should be on time in FY18

Detector simulations

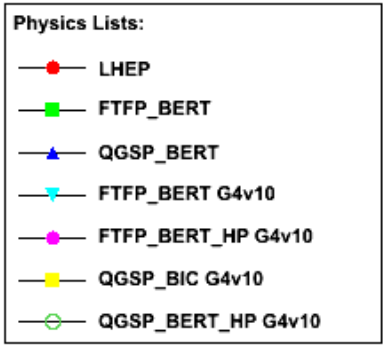


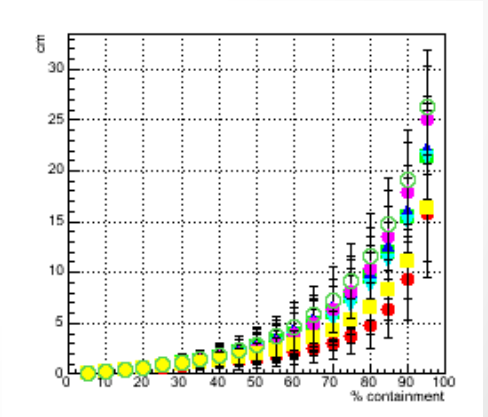
Geant4 - ESC Collaboration

- Makoto Asai: liaison between Geant4 International Collaboration and ESC / EIC
- EIC physics list and validation, tuning and extension (energy range is different from LHC!), including test beam studies



10 GeV/c p^+ radial shower size in W:
major differences between models





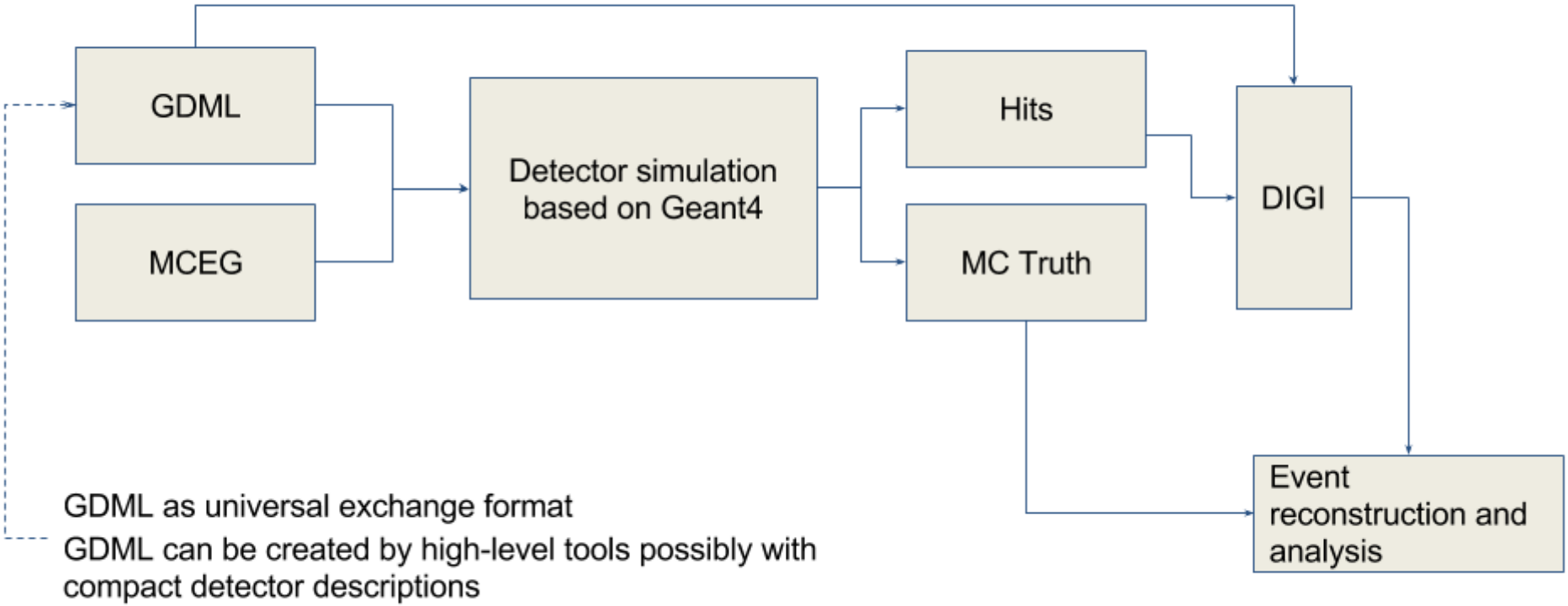
study by C. Pinkenburg

Geometry interface

Lightweight library

- that depends only on Geant4
- that can be used by any existing Geant4 framework
- that defines a minimalistic common data structure of hits

Vision



Community document released in FY17 *by* ***A.Dotti*** *(SLAC), MD (Jlab), AK (BNL), C. Pinkenburg (BNL) and other ESC contributors*

Implementation is delayed; yet should be on time in FY18

Unified track reconstruction

Modular tracking software

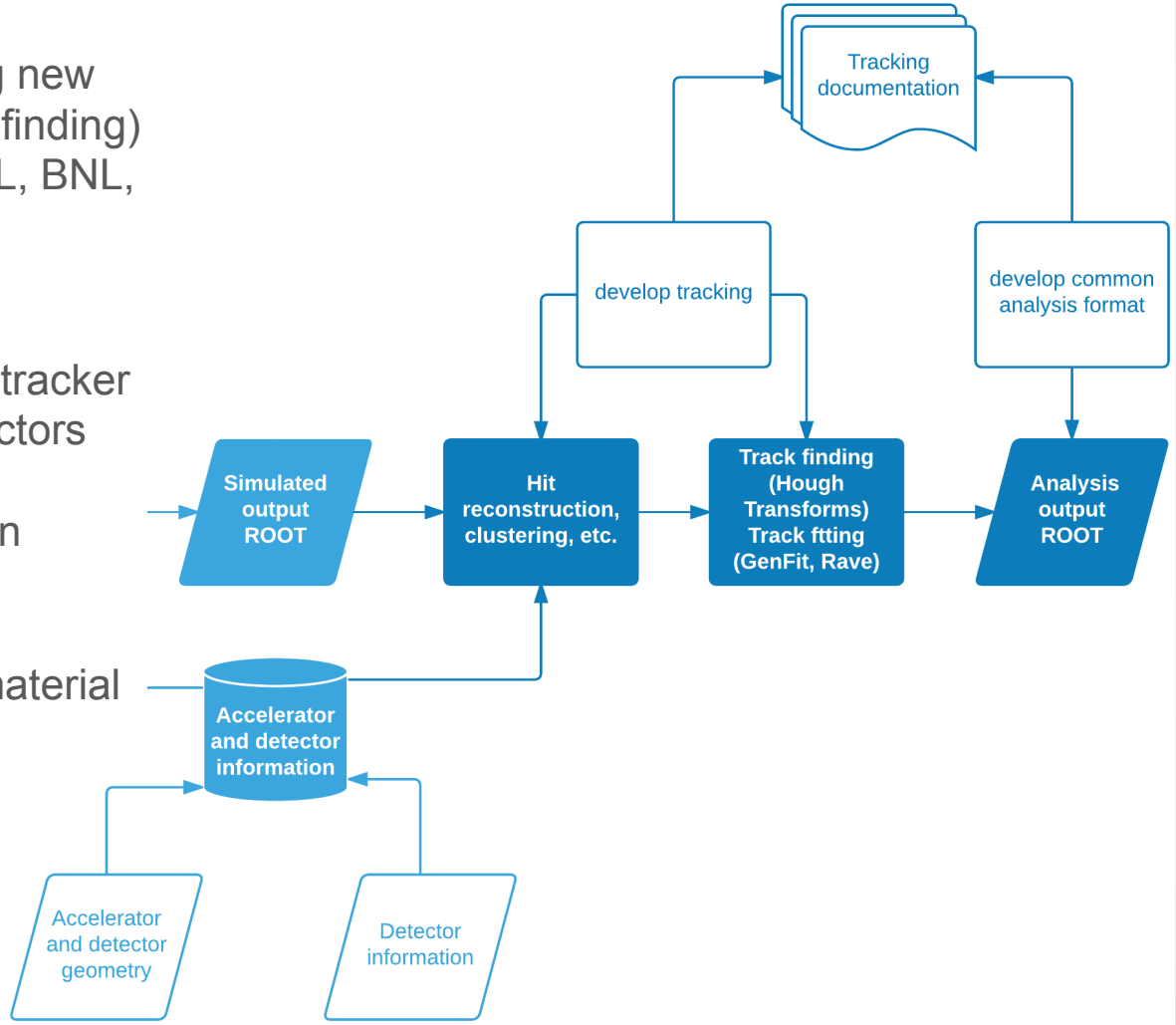
- for detector concepts and testing new algorithms (e.g., (D)NN for track finding)
- based on EIC tracking tools (ANL, BNL, JLab)

Completed feasibility study

- similar requirements and similar tracker outline for all proposed EIC detectors
- similar dataflow: simulation -> digitization -> track reconstruction

Started development

- define libraries and interfaces (material db, reconstructed hits)
- setup sandbox environment



ESC container project

Container technology

- **Container** := very lightweight Virtual Machine
- **Main players**
  - **Docker** industry standard, requires admin privilege on host
  - **Singularity** standard on OSG, can run entirely in unprivileged mode
  - **Shifter** (NERSC only)

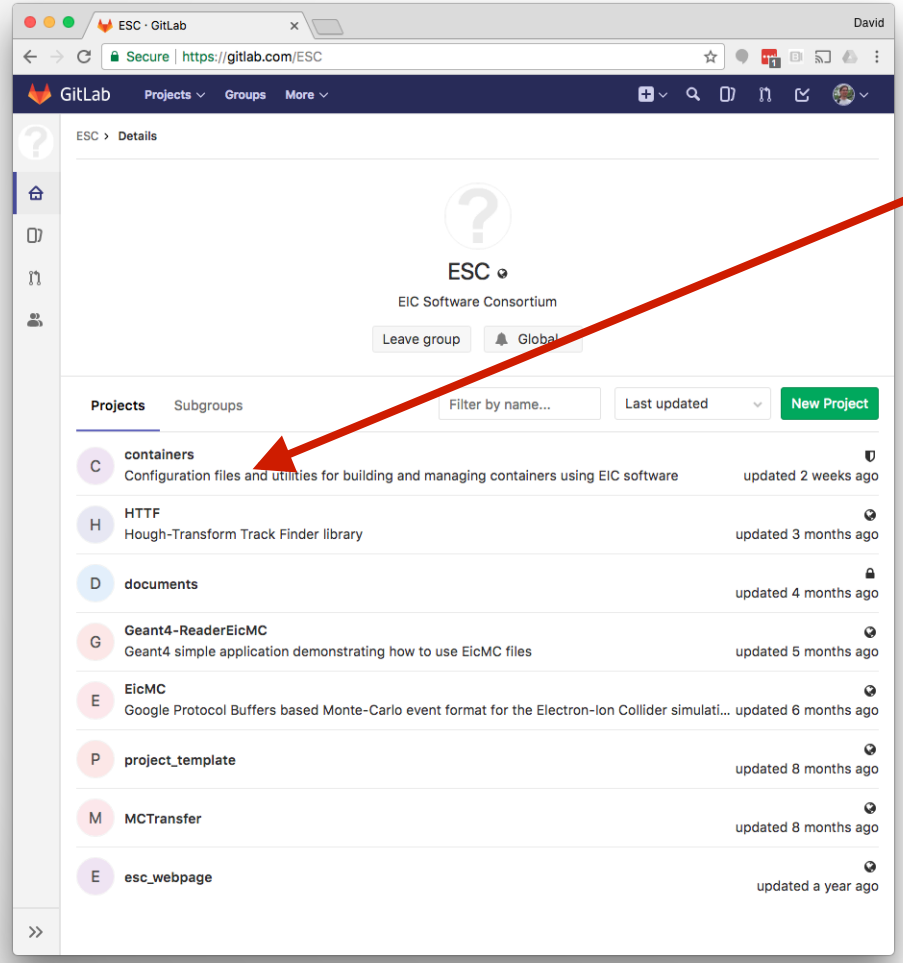
Benefits for EIC user community

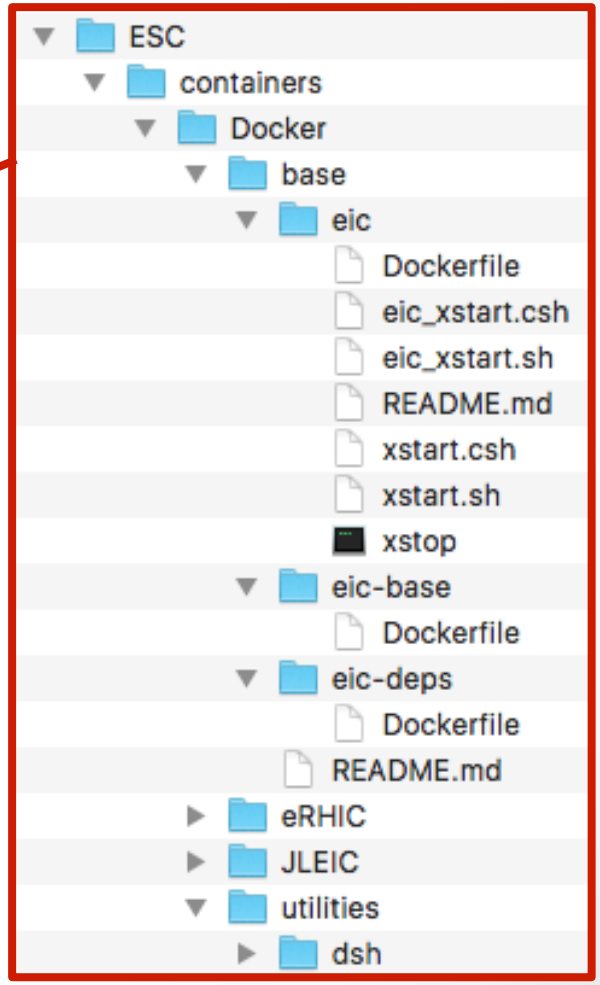
- Allow EIC users to run the same software under standardized environment on any Linux, Mac OS or Windows machine, eventually including GRID sites, commercial cloud systems, and HPC resources
- Provide consistency between software generated at different facilities
- Make it easier for new users to start working on the physics program and detector design for the EIC, by minimizing the pain of “installation overhead”

Community document draft released few weeks ago *by D. Blyth (ANL), W. Deconinck (William & Mary), MD (Jlab), A. Dotti (SLAC), AK (BNL), and* ***D. Lawrence (JLab)***

ESC container repository on GitLab

Source files for generating EIC containers are available: *https://gitlab.com/ESC*





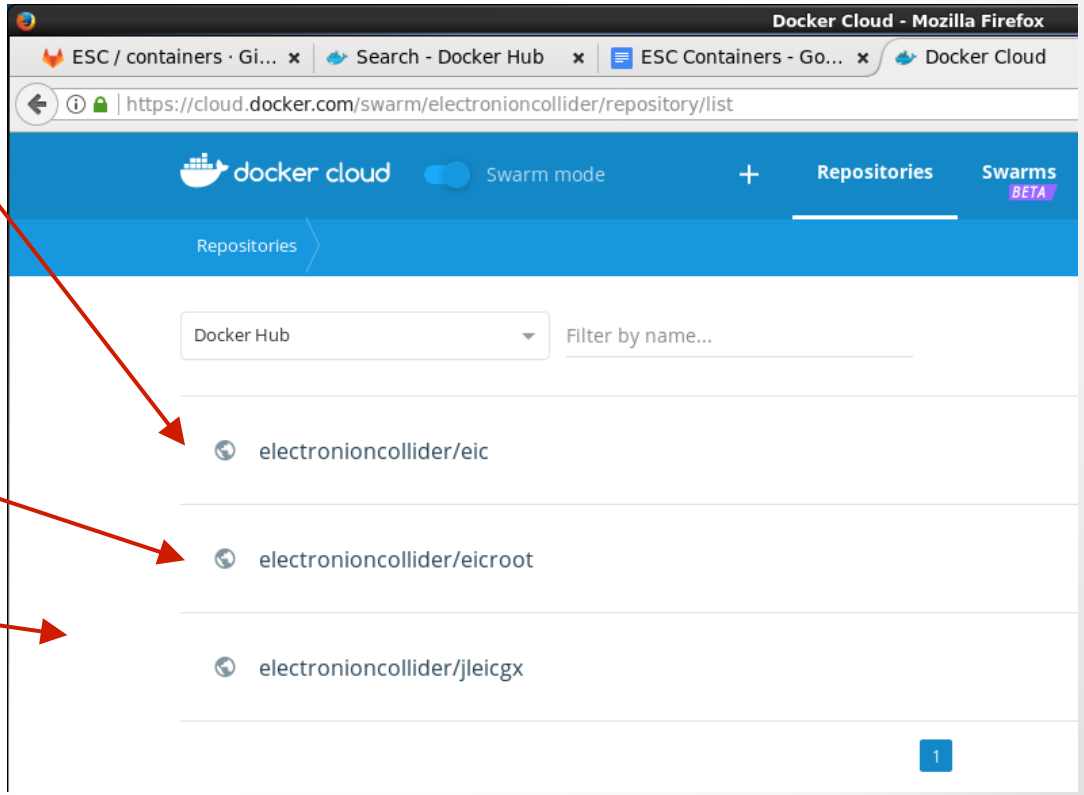
ESC container images on Docker cloud

https://cloud.docker.com/swarm/electronioncollider/repository/list

Generic base image
- based on CentOS 7
- includes:
  - ROOT 6
  - Geant4 10.3.3
  - CLHEP 2.3.4.5
  - support for OpenGL graphics

eRHIC software
- EicRoot

JLEIC software
- GEMC

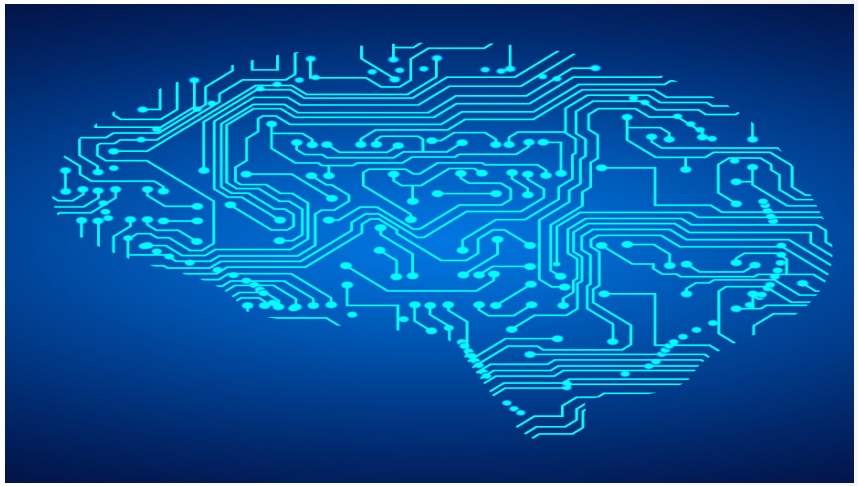


New ESC initiatives in FY18

High-performance computing

- prepare EIC HPC projects
- begin dialogue with ASCR-operated computational science user facilities

Deep neural networks



- Document selected examples for using (D)NNs at the EIC, e.g. lepton-hadron separation, RICH reconstruction, track finding, etc

The ultimate goal: be better prepared for the coming exascale computing era

Summary

Despite limited manpower we make sustained progress

- Reach out to the EIC community
- Bring existing EIC software to the end users

- Play active role in software-related workshop organization

- Gain missing knowledge and apply it to practical tasks
- Arrange expert discussions and come to a consensus-based decisions

- Take measures to prevent future EIC software divergence
- Try to establish forward looking vision of EIC software

In general should be on time with all our FY18 goals

Backup slide

eRD1

- Extensive microscopic modeling of sampling EmCal & HCal prototypes
- Neutron flux & radiation dose estimate at the eRHIC IR

eRD6

- FLYSUB test run data analysis - BNL, FIT & UVa prototypes; Coulomb scattering, etc
- Work with UVa & FIT students on Cr-GEM simulations, just started
- *(Several software pieces for the zigzag project - modeling, data analysis, etc)*

eRD12

- *(EicRoot software support for eRHIC IR studies)*

eRD14

- dRICH software library accomodation in the standalone EicSandbox G4 environment
- Work on mRICH implementation in EicRoot, just started

eRD18 *(& potentially for eRD16)*

- EicRoot software support for silicon tracker modeling